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Núm. 994
2017

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A RANK APPROACH FOR STUDYING CROSS-CURRENCY BASES AND THE COVERED INTEREST RATE PARITY

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ABSTRACT. We use the recently developed panel rank-cointegration test proposed by Pedroni et al. [2015] to check for the stability conditions of the cross-country money market interest rate bases. Using weekly information on short-term interest rates and spot and forward exchange rates for a set of 20 European economies during 2005-2017, we show that in most cases these bases are non-stationary, implying the failure of the Covered Interest Rate Parity condition. Concretely, a mean-reverting behavior is encountered in only two cases. The first includes Greece, Italy and Portugal, while the second Belgium, France and Germany.

Keywords: Covered Interest Rate Parity; Nonparametric rank tests; Cointegration; Time series panel; Cross-currency basis.
JEL Classification: C12,C33, E43.

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1. INTRODUCTION

The Covered Interest Rate Parity (*CIP*) states a relation between two countries' interest rates in the money market and their forward and spot exchange rates

$$(1+R_{d,k}) = \frac{F_k}{S}(1+R_{f,k}), \tag{1}$$

where $R_{d,k}$ stands for the nominal interest rate of the domestic country at maturity k, $R_{f,k}$ the nominal interest rate of the foreign country at the same maturity, F_k and S are the nominal forward and spot exchange rates respectively.

The *CIP* is commonly assumed to hold in international finance, as it is a benchmark for perfect capital mobility between markets and in its absence arbitrageurs could make a seemingly riskless profit.

Rearranging terms in (1) this non-arbitrage condition asserts that the FX-implied foreign funding rate is equal to the actual foreign funding rate. Hence,

$$b \equiv \frac{F_k}{S}(1+R_{f,k}) - (1+R_{d,k}), \tag{2}$$

where b represents the cross-country currency basis. Any deviation from a zero basis constitutes a violation of the parity condition. In real-life markets deviations from zero are frequently observed, partly due to the existence of transaction costs. Hence, we consider a very general case in which, under the null hypothesis the basis follows a stationary process.

Empirical evidence supporting the *CIP* became so wide-spread that by the start of the current century economists and financial professionals took it for granted. However, since the development of the recent global financial crisis, reported deviations from the *CIP* have increased in international markets. For instance, Du et al. [2016] document a persistent failure of the Libor-based *CIP* after 2007 for G10 currencies at short and long maturities. Similarly, Borio et al. [2016] show that since 2007 the basis for lending US dollars against most major currencies has been negative, confirming the violation of the *CIP* in major currency markets. Even before the global financial crisis, Skinner and Mason [2011] found violations of the *CIP* for a set of emerging markets.

There are many reasons why the *CIP* would not always hold. However, it is intriguing why a relationship that has been valid for many years has failed to remain valid in the aftermath of the global financial crisis. Empirical evidence suggests that these deviations are due to concerns regarding counterparty and credit risk in international financial markets (see, for instance, Wong et al. [2017]). However, the puzzle is that deviations have persisted even after these risks have returned to normal levels. Some authors have suggested that banking regulations can also affect the *CIP*. For instance, if banks face tight capital and liquidity requirements, even if the trade may be risk free, the *CIP* may fail to hold. Calibrating whether these deviations are efficient market violations, or simply a reflection of greater costs and risks (some of them possibly induced by regulation), has become an important challenge for financial economists.

The current literature focuses in understanding the channels explaining *CIP* failures in major markets after the global financial crisis. Most papers use very simple empirical methods for identifying failures of this parity condition, such as those based on inspection of cross-country currency bases. This methods, while attractive for their simplicity and usefulness in checking for short-run deviations, lack of power for identifying long-run deviations from the *CIP*. Additionally, they do not allow the construction of confidence intervals in order to test hypotheses of interest, such as if the basis is effectively statistically different from zero at a point in time, or time-varying within intervals. In fact, as shown in Borio et al. [2016] and elsewhere, these bases have become much more volatile in the aftermath of the global financial crisis. Hence, studying their statistical properties, i.e. checking whether they are stationary or not, is of great importance for the international finance literature.

In this paper we introduce a new method for testing the statistical properties of the basis implied by the *CIP* in the long-run. Our method relies on a cointegration rank-test proposed by Pedroni et al. [2015], which allows the identification of the number of common stochastic trends within a time-series panel. Our approach admits short-run deviations, but focuses in the proportionality of interest rates (while accounting for the spot and future exchange rates within the respective currencies) in the long-run.

We use weekly data for 20 European countries between January 2005 and March 2017.[1] We find 16 common stochastic trends for the whole dataset, suggesting the existence of four countries that share a cointegration relation with other members of the panel.[2]

Furthermore, given the evidence showing that the recent global financial crisis affected the interest rate parity and the fact that some European countries were more affected by the crisis than others, we separated our sample of countries into three groups. In the first we included the Western European economies that were arguably most affected by the crisis, namely Greece, Italy, Ireland, Portugal and Spain. In the second we included the remaining Western European countries. Finally, in the last group we included Eastern European countries. Within the first group, we find three common stochastic trends and a unique cointegration relation between Greece, Italy and Portugal. This result suggests a long-run relation among the short-term interest rates of these three countries. Additionally, as there is no cointegration relation in which Ireland or Spain appear, our results imply that the *CIP* condition is not satisfied by any pairwise relation including one of these two countries.

[1] In our dataset we have both countries whose currency is the Euro and others in which not. For the former, our approach implies stationary interest rate spreads.

[2] Initially, this result could also indicate that some of the time series are I(0). However, we performed additional tests showing that this is not the case. In particular, individual unit root tests for each series.

The existence of a cointegration relation between Greece, Italy and Portugal within the first group of countries is intuitive, as these three countries share several similar features in terms of economic growth, financial development and regulation. While Ireland and Spain share common features with the other three countries, their financial regulations and macroeconomic environment exhibit important differences. Particularly, Ireland is more closely commercially and financially integrated with the UK, and Spain has a stronger financial regulation including the existence of a dynamic provisioning system for financial institutions (see, for instance, Herrero et al. [2003]).

Regarding the second group of countries, we find seven common stochastic trends and a unique cointegration relation between Belgium, France and Germany. This result relates to the fact that these three economies are the most financially developed in Europe and maintain close financial and trade relations.

Finally, for the group of Eastern Europe economies we encounter six common stochastic trends and therefore no cointegration vector between them. Hence, for this final group, bases are all non-stationary processes.

In a similar fashion to the results of the recent literature, we show that the *CIP* condition does not hold in most cases. However, we add to this literature showing that the reasons for its unfulfillment do not rely on temporary shocks originating in the recent global financial crisis, but on more structural, long-run factors. Our results indicate that arbitrage opportunities exist between various of the markets included in our sample, and hence they are useful for structuring international financial portfolios.

The remainder of the paper is as follows. Section 2 presents the data. Section 3 introduces the econometric methods used in this paper. Section 4 describes our main empirical results, and finally the last section concludes.

2. Data

We use weekly zero-coupon one-year sovereign bond interest rates data covering the period January 2005 - March 2017 for 20 European countries listed in Table 3 of Appendix A. We focus in short-term interest rates, as the *CIP* is believed to influence primarily these rates.

We consider two sets of countries. Those for which the legal currency is the Euro and those for which not. For those countries pertaining to the first set, the *CIP* condition establishes that short-term interest rates in both countries should be identical. Therefore, in this cases we only collected information on nominal interest rates. For the second group, we constructed the *CIP* equation as in (1) using short-term interest rates and information on spot and forward exchange rates with respect to the Euro. Forward rates correspond to the price of a one-year foreign exchange forward. Table 1 presents descriptive statistics of the interest rate series used in our empirical model.

TABLE 1. Descriptive statistics of short-term interest rates

	Mean	*Sd*	*25%*	*50%*	*75%*
First Group					
Greece	9.24%	0.076	4.57%	6.78%	11.03%
Ireland	2.80%	0.020	1.08%	2.28%	4.41%
Italy	2.30%	0.016	0.97%	1.59%	3.60%
Portugal	3.19%	0.026	1.33%	2.44%	4.51%
Spain	2.30%	0.016	0.89%	1.65%	3.63%
Second Group					
	Mean	*Sd*	*25%*	*50%*	*75%*
Austria	1.85%	0.018	0.54%	0.92%	3.13%
Belgium	1.80%	0.017	0.54%	0.94%	3.05%
Denmark	1.80%	0.017	0.51%	0.91%	3.12%
France	1.74%	0.018	0.45%	0.80%	2.94%
Germany	1.67%	0.018	0.37%	0.72%	2.88%
Netherlands	1.71%	0.018	0.43%	0.80%	2.94%
Norway	1.54%	0.018	0.21%	0.56%	3.08%
Switzerland	2.09%	0.018	0.79%	1.17%	3.63%
UK	1.44%	0.017	0.18%	0.59%	2.43%
Third Group					
	Mean	*Sd*	*25%*	*50%*	*75%*
Czech Republic	1.44%	0.014	0.17%	1.25%	2.49%
Poland	2.25%	0.017	0.78%	1.47%	3.65%
Slovak Republic	2.41%	0.019	0.86%	1.58%	3.90%
Slovenia	2.67%	0.017	1.23%	2.32%	4.22%
Russia	1.19%	0.033	-0.16%	0.59%	3.68%
Turkey	3.17%	0.016	1.83%	2.76%	4.78%

Authors' calculations. 25% 50% 75% represent the respective quantiles of the distribution.

3. Econometric Methodology

We use the *MMIB* rank test proposed in Pedroni et al. [2015] to find the number of common stochastic trends present in the panel. We assume that the data generating process can be written as follows[3]

$$\mathbf{y}_t = \boldsymbol{\alpha}_t + \mathbf{u}_t \quad \forall t \in \{1...T\} \tag{3}$$

Where $\mathbf{y}_t$ is a $N \times 1$ vector of time series, $\boldsymbol{\alpha}_t$ represents a $N \times 1$ deterministic term, and $\mathbf{u}_t$ is a $N \times 1$ stochastic term. Furthermore, we assume that the panel has c common stochastic trends. So in particular, there exists a $N \times N$ orthonormal matrix $\mathbf{C}$ such that $\mathbf{C}'$ rotates $\mathbf{u}_t$ into a I(0) $(N-c) \times 1$ vector and a I(1) $c \times 1$ non-cointegrated vector.

The *MMIB* statistic used to test the null of c common stochastic trends against the alternative of less than c is

$$MMIB \equiv 2T \sum_{i=N-c+1}^{N} \hat{\lambda}_i, \tag{4}$$

where $\hat{\lambda}_1 \geq ... \geq \hat{\lambda}_N$ are the ordered eigenvalues of $\hat{\boldsymbol{\Sigma}}_p \hat{\boldsymbol{\Omega}}_p^{-1}$ ordered according to decreasing absolute value. And the matrices $\hat{\boldsymbol{\Sigma}}_p$, $\hat{\boldsymbol{\Omega}}_p$ are the contemporaneous and untruncated[4] long-run variance estimators, respectively.[5]

$$\hat{\boldsymbol{\Sigma}}_p \equiv \frac{1}{T} \sum_{t=1}^{T} \hat{\mathbf{u}}_t \hat{\mathbf{u}}_t', \qquad \hat{\boldsymbol{\Omega}}_p \equiv \frac{2}{T^2} \sum_{t=1}^{T} \hat{\mathbf{S}}_t \hat{\mathbf{S}}_t' \tag{5}$$

Where $\hat{\mathbf{S}}_t \equiv \sum_{s=1}^{t} \hat{\mathbf{u}}_t$ and $\hat{\mathbf{u}}_t$ represents the OLS residuals of the regression of $\mathbf{y}_t$ on $\boldsymbol{\alpha}_t$.

The critical values of the statistic are calculated through the use of response surface regressions as in Pedroni et al. [2015].

4. Empirical Results

The main purpose of this paper is to study the stochastic properties of the cross-country currency bases and test for the validity of the *CIP* condition for a set of 20 European economies. For this purpose we use the rank-cointegration method proposed by Pedroni et al. [2015], which was described in the previous section. When the full dataset is used, 16 common stochastic trends are encountered (see Table 2). In other words, we find evidence supporting the existence of a cointegration relation of the series of four countries with other members of the panel.

In order to identify countries that share stochastic trends we separate our sample into three groups, each one of them containing a set of more homogeneous European countries. The first group is

[3] The deterministic term in Equation (3) can be augmented with a higher degree polynomial trend function as in Pedroni et al. [2015].

[4] Untruncated in this context means that the bandwidth for the long-run variance estimator is taken to be equal to T.

[5] We assume that the long run variance estimator is calculated using the Bartlett kernel. In this case, the expression for $\hat{\boldsymbol{\Omega}}_p$ simplifies as shown by Kiefer and Vogelsang, 2002.

composed by Greece, Italy, Ireland, Spain and Portugal, arguably the countries that were most affected by the recent global financial crisis. The top-left panel of Figure 1 presents the behavior of normalized short-term interest rates for this group of countries. A notable feature is that interest rates in Greece are much higher than in the other countries. However, interest rates in this group of countries behave similarly during most of the time, especially before the global financial crisis. This goes in line with the findings of several papers that show the fulfilment of the *CIP* condition before 2007.

The second group contains the other 9 Western European economies, among which Germany is included. The bottom panel of Figure 1 shows their normalized short-term interest rates. Finally, our third group comprises Eastern European countries (Top-right panel of Figure 1 shows their normalized interest rates). Simple eye-inspection shows that these interest rates behave heterogeneously.

TABLE 2. Cointegration Rank Test Results

	CST	**# of Countries**
Total	16	20
First Group	3	5
Second Group	7	9
Third Group	6	6

Authors' calculations. CST denotes common stochastic trends.

Among the first group of countries, our results indicate the existence of three common stochastic trends. We identify a cointegration relation between Greece, Italy and Portugal, suggesting that the money market interest rates among these countries share a long-run stable relation. Additionally, our findings reject the *CIP* condition for the remaining countries, including Ireland and Spain. The fact that a cointegration relation exists between Greece, Italy and Portugal does not imply the satisfaction of the non-arbitrage condition for these countries. It only implies that a linear combination among these three countries' interest rates is mean-reverting. The top panel of Figure 2 exhibits these normalized short-term interest rates.

The existence of a cointegrating relationship between Greece, Italy and Portugal is not surprising, as these countries have well-integrated money markets and exhibit similar macroeconomic and financial conditions. Meanwhile, Ireland is geographically and financially closer to the UK and Spain has important differences in terms of financial regulation.

For the second group we find seven common stochastic trends, and a unique cointegration relation between Belgium, France and Germany. These results go in line with those of Baum and Barkoulas [2006] who tested the German dominance hypothesis and found that Germany's short-term interest rates are fractionally integrated with those of Belgium, France, Ireland, Italy and the Netherlands. The bottom panel of Figure 2 exhibits normalized short-term interest rates for these countries.

Finally, and in contrast with results for the two other groups, there is no cointegration relation for the set of Eastern European economies. This result suggests the invalidity of the *CIP* condition for these countries and the existence of arbitrage opportunities available within these countries' money and exchange rate markets.

Our findings provide novel insights for the international finance literature as they show evidence of non-stationarity of the cross-country currency bases for most European economies. Hence, we add to the papers that have shown that these bases are different from zero by showing they are not mean-reverting. This result suggest the need for further research on the risk-related determinants of these bases and their potential change after the recent global financial crisis. Specifically, recent papers have suggested that the observed persistent deviations from the *CIP* condition are a temporary phenomenon that will eventually revert.[6]

[6] For instance, Baba and Packer [2009] attribute the failure of *CIP* during the global financial crisis to differences in counterparty risk between European and US financial institutions while Coffey et al. [2009] call the attention on the existence of capital constraints.

FIGURE 1. Normalized interest rates for the three groups of countries

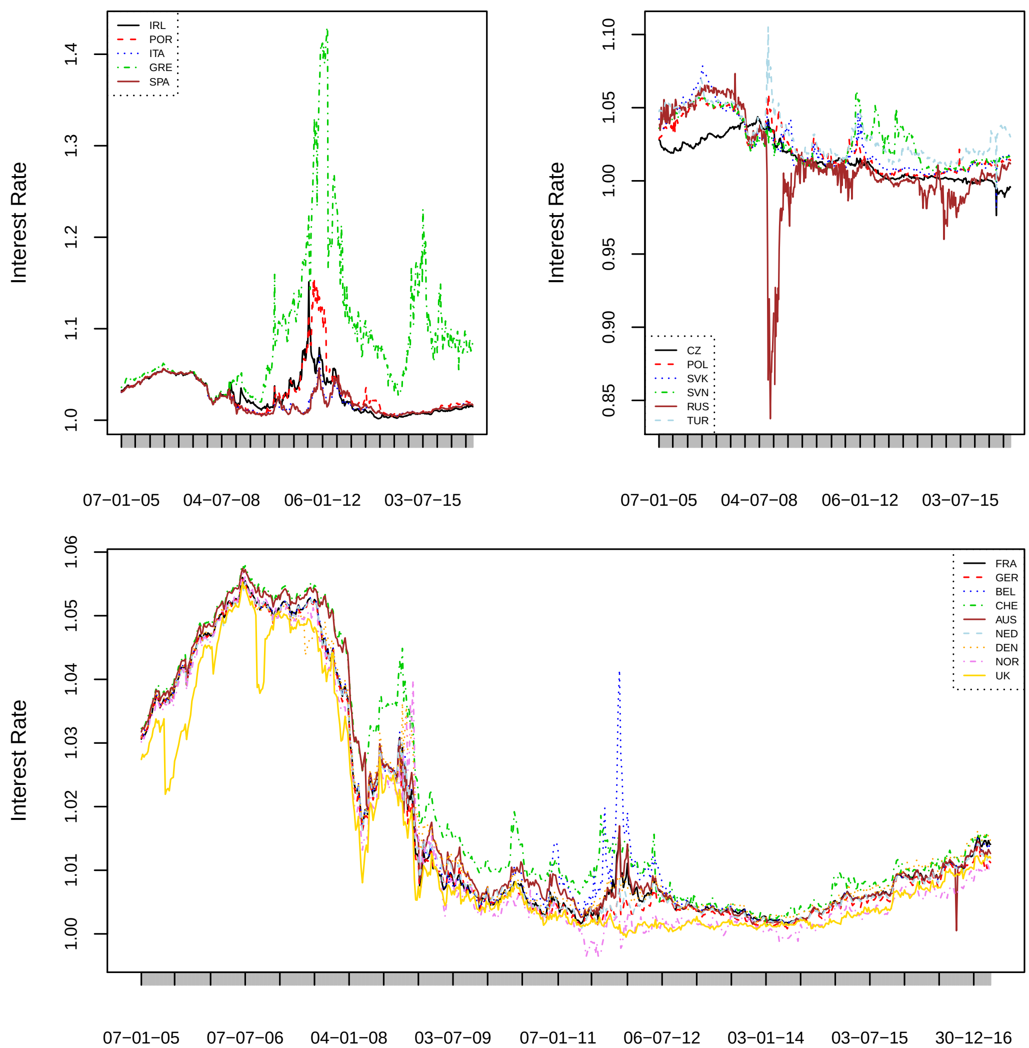
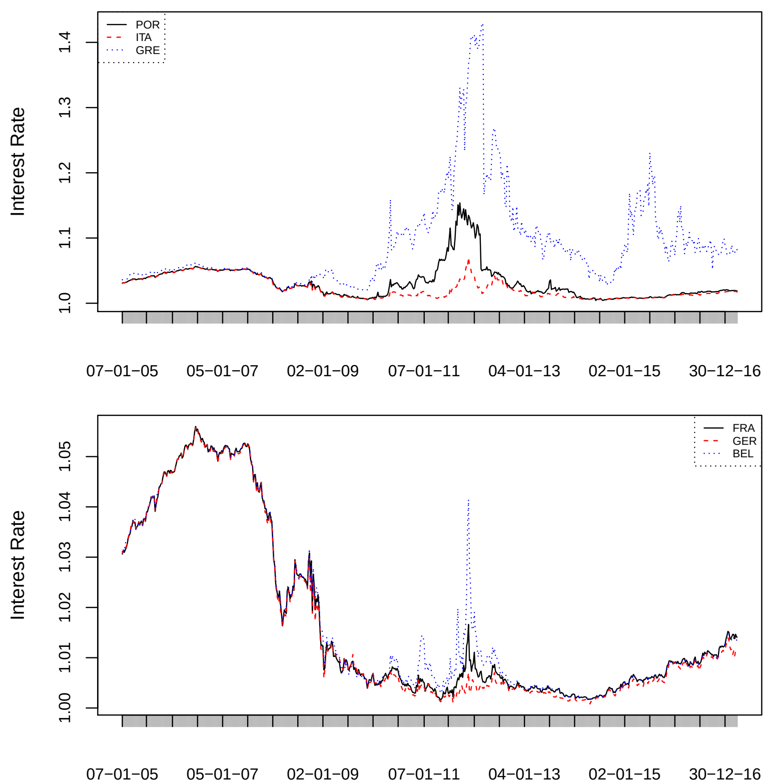


FIGURE 2. Normalized interest rates for the countries in the cointegration relations



5. CONCLUDING REMARKS

This paper studies the stochastic properties of cross-country currency bases for a set of 20 European economies between 2005 and 2017. We develop a methodology based on the rank-cointegration test proposed by Pedroni et al. [2015]. Our results show the existence of cointegration relations for two different sets of countries. On the one hand, we find a long-run relationship between the short-term interest rates of Greece, Italy and Portugal, which are among the most affected countries during the recent global financial crisis. On the other hand, we identify a long-run relation between Belgium, France and Germany.

Our findings add to the recent literature on the failure of the *CIP* condition by providing evidence of non-stationary behaviors of the cross-country currency bases for most European economies. Our results call for further research on the risk-related determinants of these bases and their potential change after the recent global financial crisis.

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APPENDIX A. COUNTRIES CONSIDERED

TABLE 3. Countries

First Group		**Second Group**		**Third Group**	
Greece	*GRE*	Austria	*AUS*	Czech Republic	*CZ*
Ireland	*IRL*	Belgium	*BEL*	Poland	*POL*
Italy	*ITA*	Denmark	*DEN*	Slovak Republic	*SVK*
Portugal	*POR*	France	*FRA*	Slovenia	*SVN*
Spain	*SPA*	Germany	*GER*	Russia	*RUS*
		Netherlands	*NED*	Turkey	*TUR*
		Norway	*NOR*		
		Switzerland	*CHE*		
		United Kingdom	*UK*		


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